5/84

PERSONAL COMPUTER NETWORKS: AN EXECUTIVE BRIEFING FROM NESTAR

EXECUTIVE SUMMARY

Mainframe computers have inherent limitations which make them less than ideal in providing computer support to all levels of a corporation. Multi-user minicomputer systems are better for this function and less costly. Individual personal computers are an ideal means for increasing personal productivity at a very low cost. However, they lack the multi-user advantage of a shared database, and they require expensive duplication of hardware.

Local area networks linking personal computers preserve all the benefits of individual personal computers, permit standardization on the personal computer issue without discouraging innovation, and permit cost-efficient sharing of hardware and data. There are a number of technical issues which must be addressed in order to make an intelligent decision concerning local area networks. This briefing outlines these issues in non-technical terms.

PERSONAL COMPUTER NETWORKS: AN EXECUTIVE BRIEFING

Introduction

One of the greatest challenges to business in the Information Age is the integration of computers at all levels into a productive system that fosters profitability. Achieving the connecting, sharing and distributing required to do this is the task of Local Area Networks.

The first part of this briefing discusses the advantages and disadvantages of the three most common delivery systems for computer support: mainframe computers, minicomputer systems, and individual personal computers. The second part of this briefing reviews the important engineering issues related to personal computer networks.

PART ONE–HISTORICAL BACKGROUND

The Centralized Mainframe Computer

The first approach to delivering computer support to large numbers of people was the connecting of many, many terminals to a single, large mainframe computer. Mainframe computers, designed with the idea of automating massive clerical tasks, have never been an effective means of providing support to managers. They have to be programmed by experts; and even when properly programmed, they have inherent limitations which make them quite imposing for nontechnical people to use.

Multi-User (Minicomputer) Systems

Multi-user (minicomputer) systems evolved from mainframe star configurations as hardware became smaller, cheaper, and more powerful. These systems applied the principles that worked for corporations as a whole to single departments.

Advantages of Multi-User Systems

Multi-user systems offered many advantages over the previous generation of mainframes, including:

1. **Cost.** Multi-user systems made computing affordable to much smaller entities, e.g. small companies, single manufacturing plants, etc.

2. **Local/divisional independence.** Multi-user systems also brought a new degree of computer independence to such entities, because the lower cost eliminated the need for senior management to approve a purchase.

3. **Increased access.** Because of their lower cost, multi-user systems gave more people access to computer power.

4. **File sharing.** With the minicomputer came a whole new class of applications based on file sharing. For example, a newspaper office could be

conceived where the story was written on one terminal, passed on to an editor at the next, then on to a typesetter at a third, and so on.

Problems with Multi-User Systems

Multi-user systems are typically *not* a replacement for an existing mainframe, but a supplement. Indeed, multi-user systems suffer from most of the same problems as mainframes.

1. **Response time.** Response time–the amount of time any individual "user" has to wait before he receives a response to input–may degrade severely when the system is operating near capacity (in terms of the number of terminals on-line) or during certain specific operations that tax the system's resources.
2. **Expansion costs.** Up to a certain point, the cost of adding a new user is the cost of adding a new terminal–usually in the $1000 to $2000 range. However, once the system reaches its limit, the cost of adding one more terminal requires a new CPU, which can cost over $100,000. The mechanics of the budgeting process often make it impossible for managers to make this "balloon payment" without going through a lengthy approval process.
3. **Flexibility.** The selection of off-the-shelf software for multi-user systems is limited. Furthermore, as with mainframe computers, experts are required to install and maintain this software. Most significantly, multi-user software is expensive, frequently costing ten times as much as programs for personal computers that perform exactly the same task!
4. **System crash.** The dependence of an entire branch, division, or factory on the continuous functioning of one machine is by far the greatest weakness of multi-user systems.

Individual Personal Computers

The advantages that individual personal computers bring to corporations are well known, but here is a brief review: Personal computers dramatically increase the personal productivity of people at every level in an organization. They fit on a desk top and require no special environment. Employees respond favorably to them, whereas they often reject a "dumb terminal." Their ease of use makes it possible to computerize functions that previously had to be done without computer support. Software is now available for almost every business function. Finally, because of their low cost, a purchase can usually be authorized at the lowest decision-making level.

Disadvantages

1. **Duplication of resources.** Personal computers require peripherals such as printers. A department with five people using five personal computers may require five printers–although those printers will only be used about 20 minutes a day.

The same situation applies to data storage. The most common means of storage for personal computers, the floppy disk drive, is the least efficient on a cost-per-unit-of-data-stored (cost-per-byte) basis.

2. **Duplication of databases.** When personal computers are isolated, their databases (customer lists, inventory, engineering data), must be separately created and maintained. Even if the customer list exists in the company's mainframe computer, it has to be typed into the departmental personal computer line by line.

Beyond this fundamental inefficiency, there is the problem of data integrity. Once separate customer lists exist, what mechanism will assure that they are all the same?

3. **"Computer Anarchy."** In addition to these two specific disadvantages, multiple, individual personal computers pose other serious management problems associated with non-standardization.

PART TWO–LOCAL AREA NETWORKS

A local area network is a collection of individual computers–usually personal computers–which are connected so that they can communicate with one another and with shared network resources such as mass storage units, printers, modems for communication over telephone lines, and "gateways" to other networks or mainframe computers.

System Components

While all local area networks differ in details, they all consist of the same basic components, which are described below:

- **A Winchester hard disk drive.** This is the mass storage unit that contains all the data in the system.
- **A back-up storage system** such as a streaming tape drive, which is used to regularly archive the contents of the hard disk.
- **A file server.** This is a computer which manages access to the hard disk as well as other network functions. The term file server may refer (1) only to the dedicated computer and the software that controls it, (2) to the computer/software and the disk drive, or (3) to the computer/software, the disk drive, and the back-up storage unit.
- **One printed circuit board for each computer** in the network. These boards plug into expansion slots inside the computer. They contain the "intelligence" which allows each individual personal computer to interact with other components in the network (other computers, printers, modems, etc.)
- **Intermediary devices.** These devices–often called wiring concentrators or hubs–are common in larger networks. They serve as electrical connection points for a number of PCs and peripherals in one location, e.g. one floor of a building. In some networks they also play a role in traffic management and peripheral control.
- **The computers themselves.** These are typically all the same brand and model, although some netwoks permit more than one brand of computer.
- **Software.** The most important component of all is the software which allows the sharing of peripherals and the transfer of data from computer to computer.

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NETWORK ISSUES

Physical Network Design: Topology

The term topology refers to the way the components of the network are connected. There are three popular topologies: the star, where nodes radiate from a central control unit; the ring, which has a self-explanatory name; and the bus, which is like a branching tree.

Cable

Twisted pair cable is like telephone wire. It is the least expensive type of cable to install. Indeed, some networks can make use of a building's existing twisted-pair cable. On the other hand, twisted-pair cable limits both the speed and physical length of a network. Also, it usually isn't shielded, and therefore emits electromagnetic radiation that can affect the performance of other office equipment.

Coaxial cable is the type of cable used to carry video signals. It has much greater capacity in terms of channels, is faster, and permits a network that is geographically bigger than a twisted-pair network. Coaxial cable is slightly more expensive, but as a percentage of total network cost the cabling is typically less than 5%.

In the future, fiber optic cable is expected to play an important role in high-capacity networks due to its electrical noise immunity, communications security, distance advantages, and small physical size.

Bandwidth: Broadband vs. Baseband

There are two popular technologies for transmitting signals over the network cable: broadband and baseband. In very crude terms, broadband technology makes use of many "small" channels, while baseband technology uses one "big" channel. Broadband technology is far more complex (and expensive) than baseband, and in the vast majority of cases would not be economical as a technology for networking personal computers.

Data Rates and Throughput

Data rates and throughput are complex technical issues, and their specifications can be misleading. The data rate of networks can vary from 300 bits per second to over 100 million. These numbers are difficult to evaluate for two reasons. Firstly, networks are comprised of many components, and the way they function as a system can dramatically change the performance of any one component. More importantly, performance figures are simply not meaningful except in relation to an actual situation. It is important, therefore, to determine the desired performance in business terms such as minimum number of invoices transmitted per hour, maximum time an operator must wait for a response, etc.

Network Access: CSMA/CD vs. Token Passing

Obviously, there will be times where more than one computer wants access to a channel, and this "contention" must be managed. The CSMA/CD (Carrier Sense Multiple Access with Collision Detection) approach uses the same rules people use in ordinary conversation. When one computer is "talking," all the others have to "listen." If two computers start to talk at exactly the same time–if there is a "collision"–then both stop, wait a random interval, and begin again. The one who begins first then "has the floor" and the other must wait. In the token passing approach, the electronic equivalent of a physical object (the token) is passed from computer to computer. The computer that has the token is the only one allowed to talk.

Capacity

This term relates to the capacity of a network's storage unit(s)–the Winchester disk drive(s). An expert can determine how much capacity will be needed to begin. The system you choose should offer a variety of capacity options, so that you can match your needs closely, and also allow for expansion. Having capacity options is also important if you anticipate installing networks at multiple locations with different requirements.

Back-up Storage Systems

- **Hardware considerations.** In some networks, the back-up storage hardware is included within the file server, while in others this is a separate piece of hardware that must be purchased separately.
- **Software considerations.** The network can be backed up at the system level, which means making a copy of everything in the system, including all the software. Ordinarily, however, the primary concern is for back-up at the data level. Some networks only allow a complete back-up process–a copying of everything on the hard disk. This can be a time-consuming process. Other networks are more flexible, allowing incremental back-up, which only copies changes from day to day, week to week, etc.

Compatibility

There are really two compatibility issues: "vertical" compatibility with mainframes, and "horizontal" compatibility with other computers and peripherals.

- Vertical compatibility is extremely important, because much of the data individual users will need for their work may be stored in a mainframe computer. If that mainframe is an IBM computer, the network should support at least one, and preferably two IBM protocols: bisynchronous (BISYNC) and System Network Architecture (SNA). Extra benefits will be obtained if the network is also able to emulate IBM's popular 3270 terminal.
- Horizontal compatibility can be important if a network must link a variety of existing personal computers, or if some users require one brand while other users require another.

Operating Systems

Every brand of computer (and sometimes various models within a brand) has its own operating system. Some networks only support one operating system, while others support more than one, so that more than one type of computer can belong to the network. Transferring files between dissimilar computers can be easy, difficult, or impossible, depending on the network management software.

Expandability

Virtually every business that becomes involved in computer networking will want to expand its network over time. There are several issues connected with this expansion.

- Storage capacity: As the amount of data on the network grows, the network's storage capacity should be able to grow.
- Number of users: Some networks are severely limited as to the maximum number of users. Also, the theoretical maximum number may be much larger than what is practical in the context of a functioning business.
- Number of servers: the network should also be able to include multiple file servers, print servers, etc.
- Access to other networks: If your situation will require the network to communicate with others via telephone, you should investigate how easy or difficult this will be.
- Connection methodology: Adding new components or peripherals is much simpler in some networks than in others. Both the physical considerations (the difficulty of installing new wiring, etc.) and the software considerations ("reconfiguring the network") are factors.
- Cost: As noted in Part I, the incremental costs of expanding some networks are more or less constant, while others proceed smoothly up to a point and then require a very large expenditure before even one more user can be added to the system.

Network Management Software

The sophistication and depth of network management software is one of the critical factors in its total efficiency. To give just one example: Some networks allow space allocations ("volumes") of various sizes on the hard disk. In others the volumes must all be the same size, which leads to inefficient use of disk space. There are literally hundreds of such technical details, which taken all together make a huge difference in cost-effectiveness.

Security

A flexible security system to control disk access has three features: Firstly, it should allow different levels of security, e.g. public, certain groups only, single individuals only. Secondly, it should be able to grant different "privileges" to different groups. (The common privileges are READ, WRITE, CREATE, DELETE, and UPDATE.) In a typical situation, many people can read a file, but only a few are authorized to delete it. Thirdly, it should be able to assign these privileges at any level of the hierarchy.

The network should also have a means of controlling access to the file server console. This is important because, operating from this console, the network manager should be able to override the other security controls, so that if passwords are forgotten the data associated with them is still retrievable.

Third Party Software Issues

There are three very important issues relating to third party software:

- **Availability.** You cannot assume that the software that runs on a particular brand of PC will run on that same PC when it becomes a member of a network. There are two reasons for this. Firstly, the way most PC software is protected from illegal copying makes it impossible for that software to run on a network's hard disk without modifications. Secondly, the PCs in a network may not have the floppy disk drives! (This is as it should be. Two of the main advantages of a network are lower data storage costs and easy data sharing, and both are achieved by replacing floppy disks with shared Winchester hard disks.)

- **Protection Schemes.** Some networks have built-in protection mechanisms which make it easy for third party software vendors to protect their software from being illegally copied. Others lack these mechanisms. The networks that have them are far more likely to attract the efforts of software vendors when it comes to writing the next generation of network software.
- **Software tools.** In the same vein, some networks have built-in software tools which make the task of writing applications software for that network easier. These are the networks for which software libraries will grow most rapidly.

Application Software

Some networks offer software such as electronic mail, decision support, word processing, etc. bundled in as part of the total network selling price. This can be a factor in making accurate price/performance comparisons.

Service

It goes without saying that service is an important factor in selecting any complex technological product. You should be aware that there are regional networking companies that may not be suitable to your requirements if you have a national organization which may require networks in several cities scattered across the country or across international boundaries.

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SUMMARY OF BENEFITS

Establishing a communication network between personal computers is the ideal means of bringing the productivity of the personal computer to every level of an organization, while preserving the benefits of more centralized approaches to corporate computing. Nestar refers to networks that accomplish this as PLANs–Personal Local Area Networks. Their specific benefits are as follows:

1. PLANs preserve all the benefits of individual personal computers.
2. PLANs at the same time encourage corporations to develop a standard policy on personal computers, facilitate central control, and eliminate the danger of "PC anarchy"–without discouraging local do-it-yourself solutions to specific problems.
3. PLANs make file sharing practical. They can be set up to store data in a manner that is totally centralized, totally decentralized, or anywhere in between. In addition to "horizontal" transfer of data among personal computers, some networks also allow "vertical" transfer of data between personal computers and mainframes.

4. PLANs eliminate the duplication of hardware characteristic of individual personal computers.

5. Expenditures associated with the expansion of a PLAN system come in steady increments, with no major "balloon payment" as is the case with multi-user systems.

6. Maintenance is incredibly simple, normally being accomplished by swapping a spare computer for the one that has a problem.

IN CONCLUSION

As a pioneer in the local area networking of personal computers, Nestar has gone beyond the basic hardware to think through the many issues involved in making this complex technology work to solve real business problems in the real world. Besides sharing our expertise through articles in business and technical journals, seminars, and this briefing, we welcome the chance to meet directly with companies where local area networking is under consideration. We hope this briefing has been helpful, and we hope you will contact us when you are ready to explore local area networking in more detail.

ABOUT THE COMPANY THAT PREPARED THIS BRIEFING

Nestar Systems is one of the pioneers in Local Area Network technology. Since 1978, Nestar research and development engineers have worked closely with the major personal computer manufacturers to develop advanced hardware and software that addresses the increasing need for computer system integration, sharing of hardware, and cooperation among users.

Nestar's Products

The Nestar PLAN Series™ family includes systems for organizations of all sizes. All Nestar systems are upward compatible.

The PLAN 2000™ software package for small organizational units allows 2–4 IBM PCs to share the hard disk of IBM PC/XTs, and also permits printers to be shared.

The PLAN 3000™ file server for medium-sized organizations supports 3–12 (or more) Apple IIs, Apple IIIs and IBM PCs, and optionally includes 3270 emulation for communication with IBM mainframe computers.

The PLAN 4000™ file server for very large organizations supports 10–100 Apple IIs, Apple IIIs and IBM PCs. It offers all the features of the PLAN 3000 plus data storage capacity ranging from 60 megabytes to 548 megabytes.

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